# المحاضرة السادسة

# STRUCTURAL GEOLOGY OF THE WESTERN DESERT

*The Western Desert is a part of the Arabian platform where a relatively **thin Phanerozoic** sequence covers the Precambrian basement complex.*
*-The area **lacks expressive Alpine related compressional structures** in general.*
***-The exposed Mesozoic and Cenozoic rock units show a general N, NE and E regional dip** except the extreme western part of the region where the strata exhibit westward regional dip.*

## *The Boundaries*

The Arabian Platform within the Iraqi territory has long been divided into two main structural domains,:-

***1- The Stable Shelf to the west***

***2- The Unstable Shelf to the east.***

The eastern boundary of the Western and the Southern Deserts coincide within the boundary between the stable and the unstable parts of the platform.

-Buday,etal,1978 subdivided the Stable Shelf into two parts:-

*A- The western Rutbah – Jezira*

*B- The eastern Salman Zones (Fig.3).*

They placed the boundary between the stable/ unstable parts of the shelf along the eastern rim of the Salman Zone.

-This implies that the Euphrates and Abu Jir Fault Zones delineate the boundary from southern Iraq northward to the vicinity of Heet city, in the west.
-Then they extended the boundary across the Euphrates river valley, following Al-Tharthar valley northward to meet the Low Folded Zone (Hamrin – Makhul Subzone), where it dies out just south of Sinjar area (Fig.3).
***Fouad (1997 and 2000) using reflection seismic data showed that Abu Jir Fault Zone terminates against Anah Graben and it never continues northwards***.
-Therefore, it is proposed that the boundary between the stable and the unstable parts of the platform is to be along Abu Jir – Anah Fault Zones (Fig.4).

- **Anah Fault Zone** (or commonly Anah Graben) extends more than 100 Km in an East – West direction from Al-Qaim city, in the Iraqi – Syrian borders to the east of Anah city, then meet Abu Jir Fault Zone, where the zone changes direction to southeast extending for about 600 Km across the Iraqi territory towards Al-Batin lineament, northwest Kuwait.

-This proposed boundary represents the first basement involved fault zone that extends (partly) to the surface separating the stable (to the west) and the unstable (to the east) parts of the platform.
The zone had significant influence on the thickness and the distribution of the sediments across it.

Moreover, it inhibited the effect of the far field stress associated with the major collisioned phase of the Alpine Orogeny to propagate further southwest by acting as a mobile zone as will be shown later.

- This boundary, which is running parallel to the Zagros – Taurus Fold and Thrust Belt (i.e. the Arabian Plate margin) is more consistent with the regional tectonic framework of the northern part of the Arabian Plate.
- ***This is the main concept to propose that the boundary between the stable and the unstable parts of the platform to be placed along Anah – Abu Jir Fault Zone.***

## - *The Northern Boundary; Anah Graben*

- *Anah Graben is an East – West trending 250 Km long subsurface graben that is directly overlain by a similarly trending 90 Km long expressive monocline, exposing rock units as far as Middle Oligocene.*
- *The fault bounded trough display different geometries along its strike including symmetric and half graben styles, as well as inverted and non – inverted styles.*
- *The trough contains about 2000 m thick Campanian – Maastrichtian syn-rift sequence, followed by a relatively thin uniform Tertiary post-rift sequence.*

**The active graben subsidence was terminated by the end of the Cretaceous** as *indicated by the absence of faulting and the uniform thickness of the post-rift Tertiary sequence in passing across the graben.*

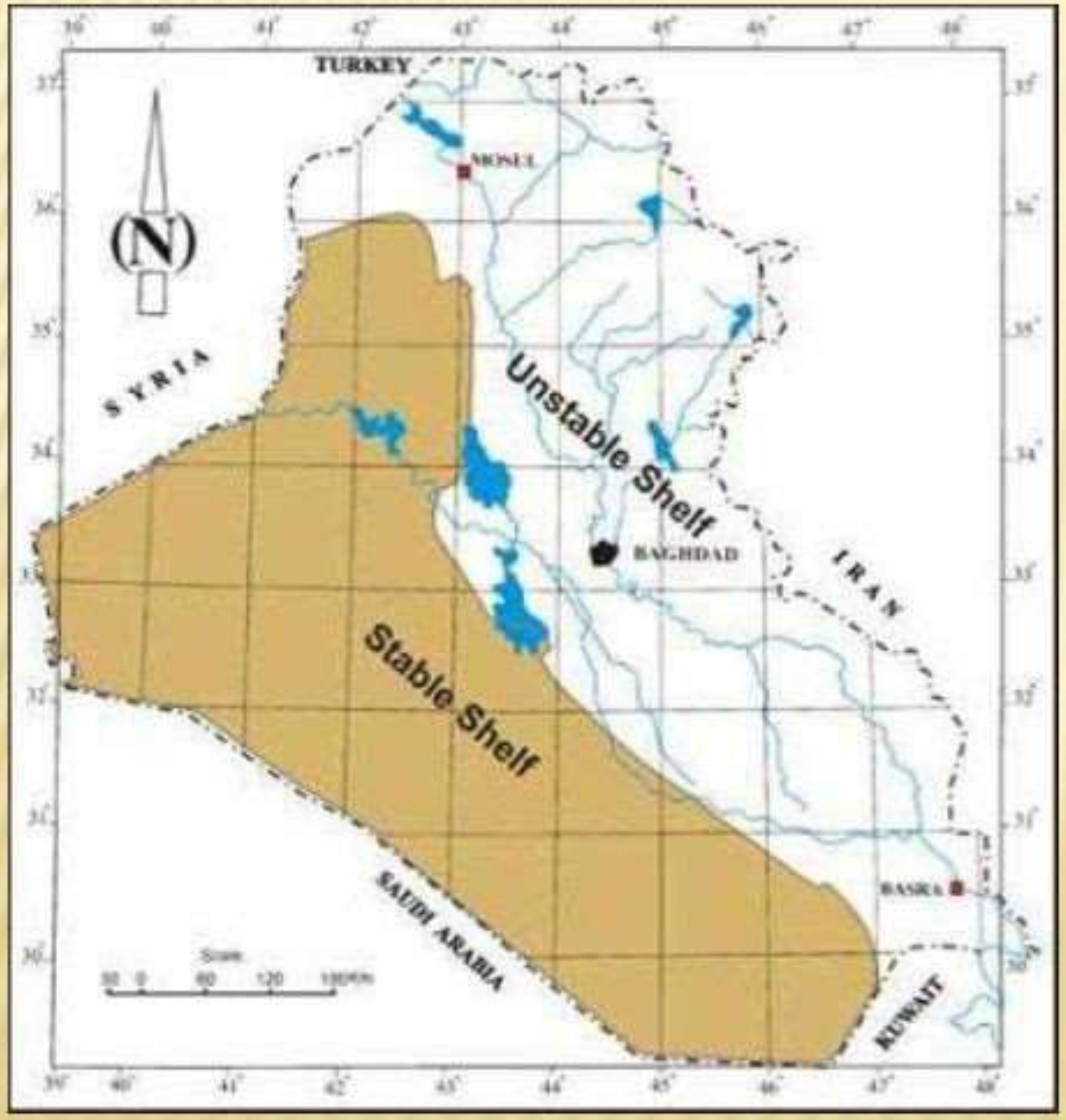
- However, during the ***Late Alpine compression*** the graben boundary **normal faults** were reactivated as **reverse faults** leading to a partial inversion of the basin and the formation of a monoclinal structure above the former basin.
- The magnitude of the reverse movement on the boundary faults was relatively small and insufficient to cancel the initial normal throw (Fig.5).
- ***Therefore, the earlier style of faulting is preserved at depth and the reverse reactivation is discernible only near the surface.***

- ***Consequently, Anah Graben display two distinct geometrical relationships;-***

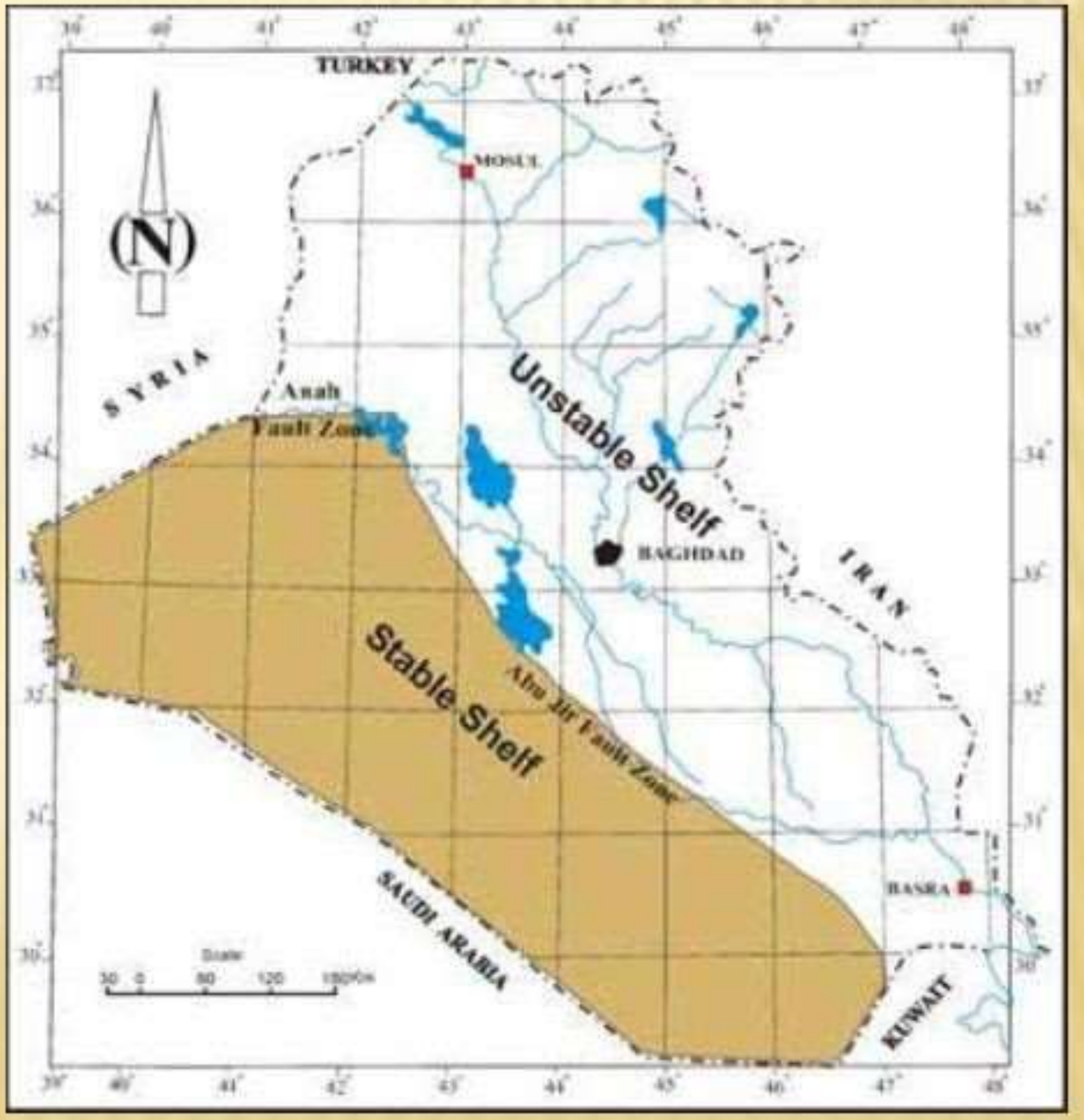
1- the complex variation in stratigraphic separation along the bounding faults.

2- and the superposition of a shallow anticlinal forced fold (Anah Monocline) directly above a thick sequence of sediment in an initially structured low.

3-The boundary between the Stable and the Unstable Shelves of the Arabian Platform(Buday& Jassim,1987)




4- The proposed boundary between the Stable and the Unstable Shelves of the platform ( Fouad,2000).



# THE EASTERN BOUNDARY; ABU JIR FAULT ZONE

The eastern boundary of the Western Desert and eventually the boundary of the stable part of the platform is considered to be ***along Abu Jir Fault Zone***.

-The zone consists of several NW – SE trending faults that extend from Anah Graben, across the Euphrates River valley to Heet, Awasil, Abu Jir, Shithatha along the western side of the Euphrates river through Kerbala, Najaf and Samawa to meet Hafr Al-Batin lineament west Basrah and northwest Kuwait.

- It forms an expressive linear feature across the Iraqi territory for about 600 Km that is clearly visible from satellite images.

***Furthermore, Abu Jir Fault Zone exhibits some geomorphological features that are directly related to the lateral movement of the zone***.

*A- The most expressive is Heet pressure ridge and the associated compressive mesoscopic structures,*

*B- as well as Awasil, Al-Jabha, Al-Mudowar and Abu Jir Depressions or sag ponds.*

***Such features are distinctive to strike-slip faults,***

# THE INTRA-STABLE PLATFORM FAULT SYSTEMS

*Anah – Abu Jir Fault Zones are considered as the* ***external fault systems*** *that bound the Stable Platform.*

*- However, several fault systems were identified within the stable part of the platform.*

*.* ***However, there are two main fault systems in the Western Desert****, the NW – SE and N – S trending fault systems.*

***1- The NW – SE Trending Faults; Hauran Strike – Slip Fault System***

*The faults of the system are very expressive on the surface and in landsat images (Fig.7).*

- *They have extremely* ***straight traces*** *extending between few to 120 Km, with some* ***sharp linear escarpments****.*
- *Moreover, many* ***valley courses and drainage channels show sharp and straight*** *offsets along these fault traces.*

*-However, careful observations point that Hauran Fault System, is strike-slip faults.*

*- The lateral movements are quite clear as the faults* ***displace the successive lithological contacts*** *(Fig.7).*

*-The displacement, which is of left-lateral nature, vary considerably along the faults ranging from few meters to 6 Km. Minor component of vertical displacement on some of these faults is also evident.*

# 7: HAURAN STRIKE-SLIP FAULT SYSTEM

*Field mapping previously had revealed the* ***presence of small anticlines and synclines*** *trending almost parallel to the fault traces.*

*-Also, Al-Mubarak, (1996) pointed to the* ***development of a series of small and large playas*** *along some of the fault traces.*

*-Such surface structures are considered as additional evidence to the recognition of strike-slip faulting.*

*Further evidence is provided by the present study by the identification of* ***a series of fault bounded silvers along some principal fault traces*** *(Fig.8).*

*-These elongated doubly tapered silvers which are known as "****horses or shear lense****s(pieces from one side of the main fault that had been sliced off and transferred along the fault zone as the displacement continue.*

*-Obviously the presence of such conclusive structures leaves no doubt about the nature of these faults.*

*-Finally, Hauran Strike-Slip Sault System displace Mesozoic and older rock units only (Fig.2), accordingly it is concluded that the fault system formed or at least reactivated during  L. cretaceous.*

# 8: ELONGATED DOUBLY TAPERED SHEAR LENSES (HORSES) ALONG THE FAULT TRACE OF HAURAN STRIKE-SLIP FAULT SYSTEM

# المحاضرة السابعة

# TECTONIC EVOLUTION

*By integrating the data already displayed, the tectonic and structural evolution of the Western Desert as a part of the Stable Platform of the Arabian Plate can be broadly outlined.*

*- Arabia as well as several continental microplates including Turkey, Central Iran, Afgan, India and other smaller fragments collectively formed part of long wide northern passive margin of the Gondwana super continent bordering the southern shore of the Paleo-Tethys ocean.*

*- These microplates remained together until the Latest Paleozoic when Gondwana start to break up.*

*-The accretion and cratonization of Arabia though out the Proterozoic (950 – 640) Ma and the following Latest Proterozoic – Earliest Paleozoic (620 – 550) Ma* ***intercontinental failure*** *and* ***strike-slip faulting*** *of Najd printed* ***two main trends*** *of weakness within the body of the continental basement of Arabia.*

*-* ***These north – south*** *and* ***northwest – southeast*** *trending lines of weakness grossly controlled the location and the style of some of the later Phanerozoic deformation.*

# THE PLAEOZOIC EVOLUTION (570 – 245) MA

-*The Cambrian* (570 – 510) *Ma is dominated by the* ***deposition of widely spread sheets of silici-clastic sediments deposited in a shallow epicontinental sea*** *in a relatively stable condition.*

- ***Exceptional event*** *occurred through the Middle Cambrian (~ 525 Ma) when global sea level rise caused the deposition of an extensive carbonate horizons (Burj Limestone) of a wide regional extent.*

-*Due to the high impedance contrast with the surrounding clastic rocks, this horizon forms a prominent reflection event, which is correlatable across much of northern .*

-*Evidence for major Paleozoic tectonic movement is spare or absent.*

-***Nonetheless, many unconformities punctuate the Paleozoic section.***

-*The unconformities are related to* ***minor epeirogenic*** *adjustments and* ***eustatic sea level fluctuation.***

- ***Because much of Arabia was covered by shallow water at that time, such events might easily cause emergence and erosion.***

*An inland sea (also known as an epeiric sea or an epicontinental sea) is a shallow sea that covers central areas of continents during periods of high sea level that result in marine transgressions ( Arabian Gulf).*

## The regional unconformities in northern Arabia are :-

1- The Late Ordovician – Early Silurian that is related to **the Arabian glaciation** and the related sea level fall .

-The unconformity is clear in Akkas1 well between Khabour and Akkas formations.

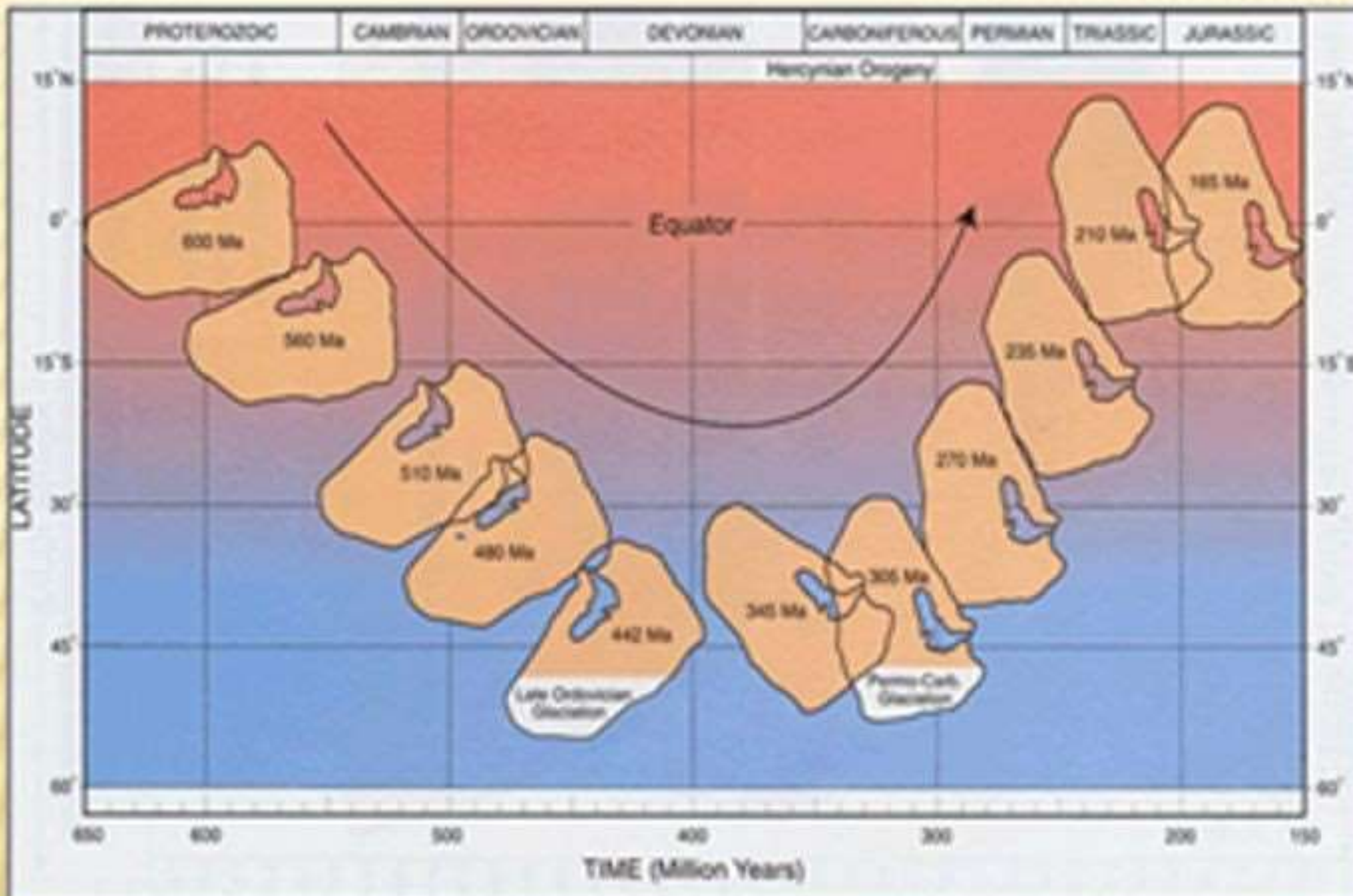
However,deglacition in Early Silurian caused regional sea level rising.

2-The second regional unconformity took place through the Late Silurian in response to **regional uplifting of the Caledonian movement**.

**3-The Late Devonian – Early Carboniferous unconformity is related to the second Paleozoic orogeny "the Hercynian movement"**.

-It is important to mention that in Arabia, the two major Paleozoic orogenic movements are identified by their effects on sea level changes, rather than by their orogenic deformation.

4-The Middle – Late Carboniferous to Early Permian unconformity was the result of the **second glaciation** of the southern part of Arabia, which caused sea level drop and exposure of considerable parts of Arabia.


PROTEROZOIC
CAMBRIAN
ORDOVICIAN
DEVONIAN
CARBONIFEROUS
PERMIAN
TRIASSIC
JURASSIC
Hercynian Orogeny
Equator
LATITUDE
15°N
0°
15°S
30°
45°
60°
560 Ma
510 Ma
480 Ma
442 Ma
Late Ordovician Glaciation
345 Ma
305 Ma
Permo-Carb. Glaciation
270 Ma
235 Ma
210 Ma
165 Ma
650
600
500
400
300
200
150
TIME (Million Years)

# LATE PALEOZOIC – EARLY MESOZOIC EVOLUTION

*At the **Late Permian** the area underwent **broad uplift** and was again exposed and eroded as a consequence of uplifting of the shoulders of the newly forming rifts that dominated the northern margin of Gondwana.*

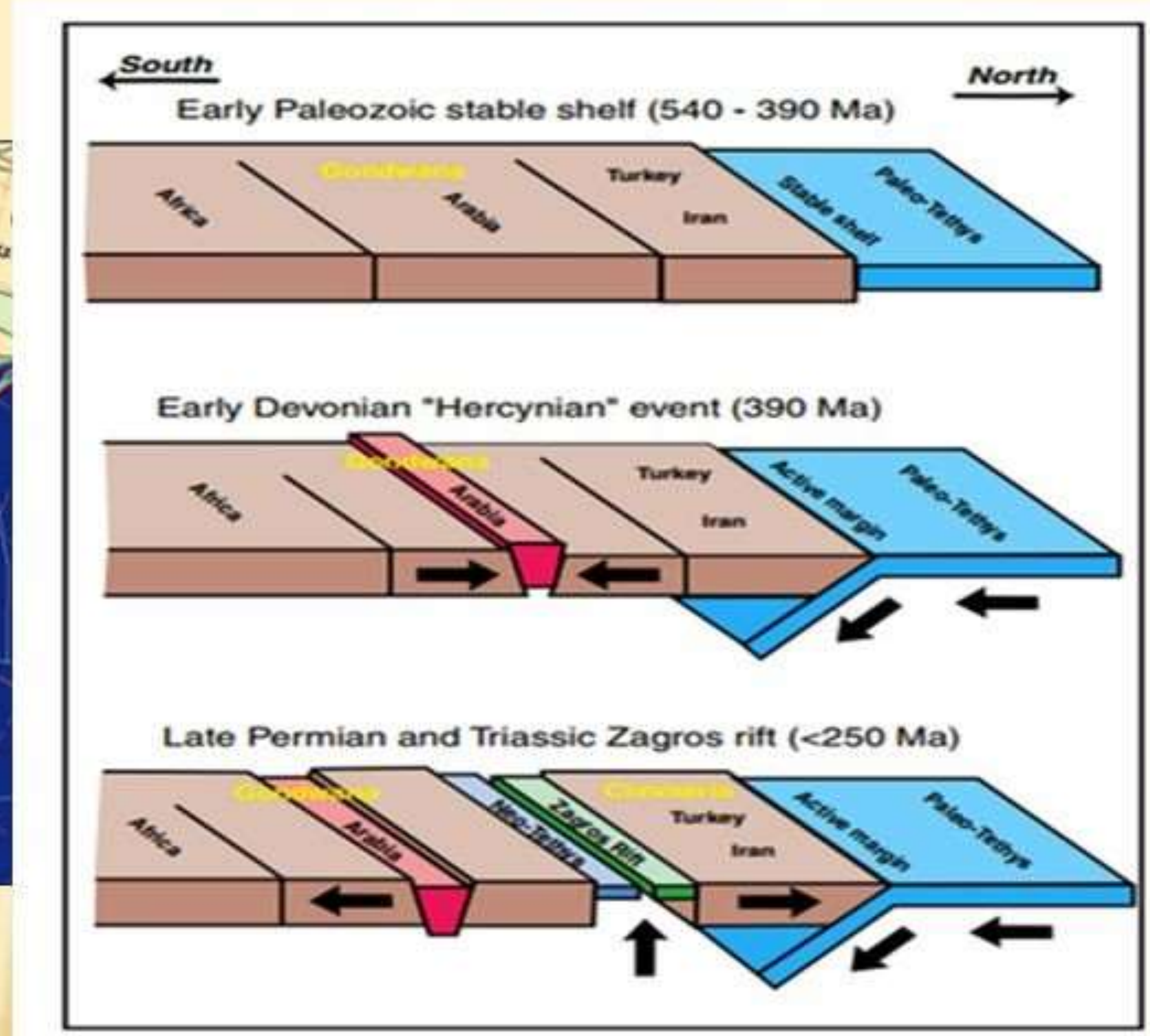
*-This was the beginning of the Neo-Tethys ocean formation.*

*- The **Cimmerian microcontinents** broke away from Gondwana towards the northeast through oceanic accretion.*

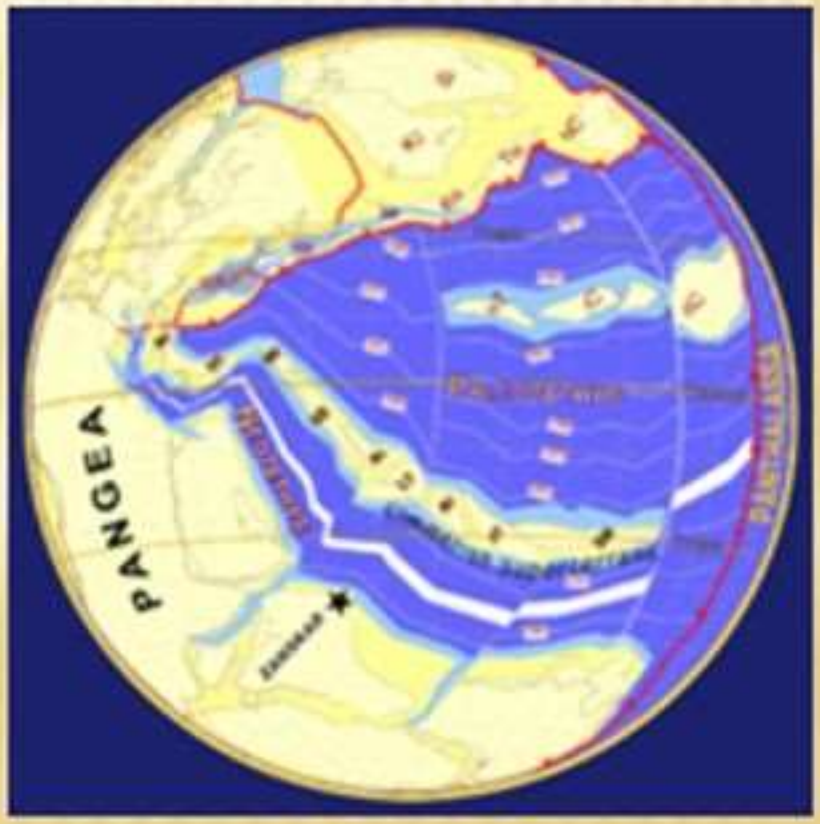
***-The opening of the Neo-Tethys continues as the Cimmerian microplates proceeded to drift northeast ward causing the shrinkage of the Paleo-Tethys as its oceanic crust subducted beneath Leaurasia.***

*- Opening of the Neo-Tethys Ocean in the Permo – Triassic brought drastic changes in the regional tectonic and sedimentation pattern of the entire Arabian plate that lasted until the final closure of the Neo-Tethys in the Late Cenozoic.*


PANGEA
PALEOTETHYS
Eastern Europe


South
North
Early Paleozoic stable shelf (540 - 390 Ma)
Gondwana
Africa
Arabia
Turkey
Iran
Stable shelf
Paleo-Tethys
Early Devonian "Hercynian" event (390 Ma)
Africa
Arabia
Turkey
Iran
Active margin
Paleo-Tethys
Late Permian and Triassic Zagros rift (<250 Ma)
Africa
Arabia
Neo-Tethys
Zagros Rift
Turkey
Iran
Active margin
Paleo-Tethys

*Cimmeria* was an ancient continent, or, rather, a string of microcontinents or terranes, that rifted from Gondwana in the Southern Hemisphere and was accreted to Eurasia in the Northern Hemisphere. It consisted of parts of what is today Turkey, Iran, Afghanistan, Tibet, Shan–Thai, and Malaya.[3] Cimmeria rifted from the Gondwanan shores of the Paleo-Tethys Ocean during the Carboniferous-earliest Permian and as the Neo-Tethys Ocean opened behind it, during the Permian, the Paleo-Tethys closed in front of it



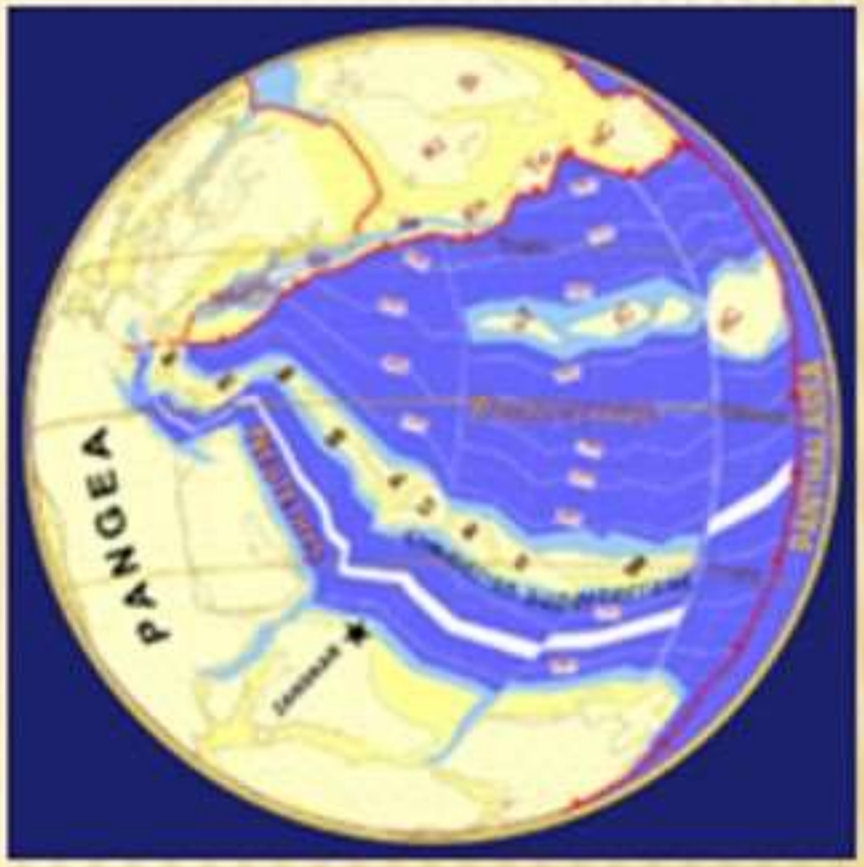




Image of Paleo-Tethys Ocean, before the Cimmerian Plate moves north, which made the ocean closed, the Paleo-Tethys Ocean closed off about 180 mya. ~290 (early permian).

The Cimmerian plate starts to move northward, closing the Paleo-Tethys Ocean, while the Tethys Ocean begins to open from the south. ~249 mya (Permian-Triassic boundary.